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(54) Title of the Invention: ELECTRIC DISCHARGE MACHINING APPARATUS

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SPECIFICATION

1. Title of the Invention

ELECTRIC DISCHARGE MACHINING APPARATUS

2. Claim for the Patent

An electric discharge machining apparatus, in which a pulse-like electric discharge is generated in a machining gap which is formed by opposing a machining electrode and an object to be machined to each other in a machining liquid in a machining tank and relative machining feeds are performed between the electrode and the object to be machined while the machining gap being appropriately maintained, whereby the object to be machined is machined, characterized in that the electric discharge machining apparatus comprises a machining tank which stores a machining liquid, at least one machining unit to which an object to be machined and a machining electrode are detachably attached and which is provided with a servo machining feed mechanism which enables relative machining feeds to be performed between the object to be machined and the electrode, a transfer device which transfers the machining unit into and out of the machining tank, a servo controller which is connected to the machining feed mechanism of the machining unit which is transferred into the machining tank and controls machining feeds, and a power supply device having a machining power circuit.

3. Detailed Description of the Invention

[Industrial Application Field]

The present invention relates to an electric discharge machining apparatus.

[Conventional Art]

In conventional publicly-known electric discharge machining apparatus, a pulse-like electric discharge is generated in a machining gap which is formed by opposing a machining electrode and an object to be machined to each other in a machining liquid in a machining tank and relative machining feeds are performed between the electrode and the object to be machined while the machining gap being appropriately maintained, whereby the object to be machined is machined. In general, this kind of an electric discharge machining apparatus has hitherto been provided with a bed, a machining tank for storing a machining liquid which is provided on the bed and in the interior of which there is provided a placement bedplate on which an object to be machined is placed, a column provided in a standing manner on the bed or on the bed side, a machining head or an arm which is supported by the column and provided on the bedplate side on the bed in an elongated manner, a feed and servo controller of a machining head to which an electrode for causing relative machining feeds in a direction opposed to the object to be machined on the bedplate to be performed is attached, a cross slide table which is provided with a controlled feed device which feeds the bedplate into a horizontal plane in a direction opposed to the electrode and in a direction perpendicular thereto, and performs positioning or machining feeds, and a machining power supply device.

However, in a case where an object to be machined is machined by using a large forming electrode for machining, it is necessary to

increase the sizes of the machining head, arm, column and the like which support the electrode and in addition, it is necessary to increase the output of the driving mechanism for the machining feed of the electrode. Therefore, the weight increases and the size of the whole apparatus increases, with the result that high-accuracy machining feed control becomes impossible, posing the problem that desired machining speed response and machining accuracy cannot be obtained. Also, conventional electric discharge machining apparatus had the problems that only one workpiece can be machined at a time and that the efficiency of working of the apparatus is low because it takes time to perform the attaching and positioning work of the large electrode and an object to be machined.

[Problems to be Solved by the Invention]

The present invention has been made from the above-described standpoint and the object of the invention is to provide a novel electric discharge machining apparatus which enables work and an electrode to be attached outside the apparatus body, enables the machining of multiple workpieces and preparations for them to be simultaneously performed, and ensures high-accuracy machining feeds and hence a high working efficiency.

[Means for Solving the Problems]

The gist of the present invention resides in constructing an electric discharge machining apparatus, in which a pulse-like electric discharge is generated in a machining gap which is formed by opposing a machining electrode and an object to be machined to each other in a machining liquid in a machining tank and relative machining feeds are performed between the electrode and the object to be machined while

the machining gap being appropriately maintained, whereby the object to be machined is machined, which comprises a machining tank which stores a machining liquid, at least one machining unit to which an object to be machined and a machining electrode are detachably attached and which is provided with a servo machining feed mechanism which enables relative machining feeds to be performed between the object to be machined and the electrode, a transfer device which transfers the machining unit into and out of the machining tank, a servo controller which is connected to the machining feed mechanism of the machining unit which is transferred into the machining tank and controls machining feeds, and a power supply device having a machining power circuit.

[Operation]

Thanks to the construction as described above, it is possible to provide a novel electric discharge machining apparatus in which high-accuracy machining feeds are performed, it becomes possible to perform preparations for another workpiece in parallel with the electric discharge machining of a workpiece, multiple machining units are arranged as required in the machining tank, efficient machining is performed, and the control of the machining liquid can be easily preformed.

[Embodiments]

Hereinafter, details of the present invention will be concretely described.

Figure 1 is a view to explain an embodiment of an electric discharge machining apparatus related to the present invention and Figures 2 and 3 are each a partial sectional view which shows an embodiment of

a machining feed mechanism of a machining unit in the electric discharge machining apparatus shown in Figure 1.

In Figure 1, reference numeral 1 denotes an electric discharge machining apparatus which comprises a bed 2, a crane 3 which is a transfer device, a machining tank 4, a machining unit 5, a forming electrode 6, an object to be machined 7, a feed controller 8 including NC control, a machining liquid 9, a machining liquid supply tank 10, and valves 11, 11. Incidentally, a machining power supply which supplies machining voltage pulses is omitted, and there are provided a connection terminal 44 to the power supply, and an energized body 45 which is energized by the fitting or folding contact of an energization part 46 provided in an appropriate position, such as a peripheral wall of the machining 4. The energization part 46 will be described later.

The crane 3 comprises a pole 12, an arm 13 and a hoist 14. The hoist 14 comprises rollers 15, 15, a motor 16, a wire 17, a hook 18 and an operation section 19.

In Figures 1 and 2, the machining unit 5 comprises a bottom plate 20, a top plate 21, a movable plate 22, support feed screws 23, 23, servomotors 24, 24 provided with a rotary encoder for detecting rotation angle, feed position and rotary speed, a PG and the like, bellows 25, 25, bearings 26, 26, holding plates 27, 27, brackets 28, 28, couplings 29, 29, eye bolts 30, 30, and a support arm 47 of the energizing part 46 having power supply connection lines for machining to the electrode 6 and the object to be machined 7, the support arm 47 not being illustrated.

The mechanism and construction of the machining unit 5 are as follows. By use of the two support feed screws 23, 23, the bottom plate 20 and the top plate 21 are fixed at an axial spacing by the

attaching of the holding plates 27, 27 and, at the same time, the support feed screws 23, 23 are rotatably attached via the bearings 26, 26 attached to the bottom plate 20 and the top plate 21. The movable plate 22 is screwed into the support feed screws 23, 23 between the bottom plate 20 and the top plate 21, the servo motors 24, 24 are attached to the top plate 21 via the brackets 28, 28, and outputs shafts 24a, 24a of the servo motors 24, 24 are connected to the support feed screws 23, 23 by the couplings 29, 29. The eye bolts 30, 30 for hitching and slinging are attached to the top plate 21, and the retractable bellows 25, 25 are attached between the bottom plate 20 and the movable plate 22, with the support feed screw 23 serving as the central axis. The object to be machined 7 is placed on the bottom plate 20, and the forming electrode 6 is attached to the movable plate 22.

Next, the operation and working operation of the electric discharge machining apparatus 1 will be described.

First, on a work bench 3 outside the machining tank 4 the worker previously places an object to be machined 7 on the bottom plate 20 of the machining unit 5, which is indicated by alternate long and two short dashes lines in Figure 1, and attaches the forming electrode 6 on the movable plate 22 opposite to the object to be machined 7.

Next, the worker performs hitching and hooking work of the eye bolts 30, 30 attached to the top plate 21 of the machining unit 5 to the hook 18 of the hoist 14 of the crane 3 by use of unillustrated wires having a thickness and a length which are appropriate, lifts up the machining unit 5 by depressing a switch of the operation section 19, causes the arm 13 to swivel, with the pole of the crane 3 serving as the central axis, moves the hoist 14 along the arm 13, and lowers as required the machining unit 5 into the machining tank 4 which stores

the machining liquid beforehand. In this case, the worker ensures that the energization part 46 at the leading end of the arm 47 provided in an appropriate position at the peripheral end of the top plate 21 fits into the energized body 45 provided in the machining tank 4 or comes into folding contact therewith, with the result that the prescribed energization occurs among a terminal 44, the electrode 6 and the object to be machined 7.

After that, the worker performs wiring from the controller 8 by mounting unillustrated connectors to the servo motors 24, 24 of the machining unit 5 and furthermore the worker performs wiring from a power supply device, which is omitted in the figure, via the connection terminal 44, the energized body 45 and the energization part 46 so that voltage pulses are supplied to across the forming electrode 6 attached to the movable plate 22 by an unillustrated power connection line and the object to be machined 7, which is attached to the bottom plate 20.

When the operation button of the electric discharge machining apparatus 1 is depressed after the finish of the above-described preparations by the worker, in the machining unit 5 synchronized driving signals are sent from the controller 8 to the right and left servo motors 24, 24, the right and left servo motors 24, 24 are rotated in synchronization, the right and left support feed screws 23, 23 are rotated from the output shafts 24a, 24a via the couplings 29, 29, the movable plate 22 is raised and lowered, the forming electrode 6 is caused to be opposed to the object to be machined 7, with a prescribed gap kept constant, voltage pulses are supplied from the power supply device to across both, and machining proceeds due to electric discharge corrosion which occurs by the supply of voltage pulses.

During the above-described electric discharge, the machining liquid 9 is supplied from the machining liquid supply tank 10 into the machining tank 4 via the valves 11, 11 so that a desired constant liquid level is maintained.

In Figure 3, reference numeral 31 denotes a machining unit which shows another embodiment other than the above-described machining unit 5. The machining unit 31 comprises a bottom plate 32, a top plate 33, a movable plate 34, support guide shafts 35, 35, bushes 36, 36, feed screws 37, 37, servo motors 24, 24, bellows 38, 38, bearings 39, 39, nuts 40, 40, brackets 41, 41, bevel gears 42, 42, 43, 43, eye bolts 30, 30, and an arm 47 having an energization part on the leading side thereof.

The mechanism and construction of the machining unit 5 are as follows. By use of the two support guide shafts 35, 35, the bottom plate 32 and the top plate 33 are attached and fixed to threaded portions 35a, 35a of the support guide shafts 35, 35 via the support guide shafts 35, 35 by screwing the nuts 39, 39 and the feed screws 37, 37 are rotatably attached via the bearings 38, 38 attached to the bottom plate 32 and the top plate 33. The movable plate 34 is screwed into the feed screws 37, 37 between the bottom plate 32 and the top plate 33 and guided to the support guide shafts 35, 35 via the bushes 36, 36. The servo motors 24, 24 are attached to the top plate 33 via the brackets 41, 41, and bevel gears 41, 41 provided in outputs shafts 24a, 24a of the servo motors 24, 24 are caused to mesh with the bevel gears 42, 42 provided in the feed screws 37, 37. The eye bolts 30, 30 for hitching and slinging are attached to the top plate 33, and the retractable bellows 38, 38 are attached between the bottom plate 32 and the movable plate 34, with the support guide shaft 35 and the feed screw 37 serving

as the center. The object to be machined 7 is placed on the bottom plate 32, and the forming electrode 6 is attached to the movable plate 34.

Next, the operation of the machining unit 31 will be described.

When the operation button of the electric discharge machining apparatus 1 is depressed after the finish of the same preparations as described above, in the machining unit 31 synchronized driving signals are sent from the controller 8 to the right and left servo motors 24, 24, the right and left servo motors 24, 24 are rotated in synchronization, the right and left feed screws 37, 37 are rotated via the bevel gears 41, 41 provided in the output shafts 24a, 24a and the bevel gears 42, 42 which mesh with the bevel gears 41, 41, the movable plate 34 is raised and lowered, the forming electrode 6 is caused to be opposed to the object to be machined 7, with a prescribed gap kept constant, voltage pulses are supplied from a publicly-known power supply device (not shown) to across both, and machining proceeds due to electric discharge corrosion which occurs by the supply of voltage pulses.

Incidentally, the constitution of the present invention is not limited to the above-described embodiments. For example, the support feed screws 23, feed screws 37 and support guide shafts 35 of the machining units 5, 31 may be provided in quantities of 3 or 4. On the other hand, it is possible to adopt a construction in which a transfer device is provided in the center, an annular machining tank is provided around the transfer device, and multiple machining units are provided in the interior of the annular machining tank to perform machining. Or alternatively, it is possible to adopt a construction in which a large machining tank is provided and multiple machining units are arranged

within the machining tank to perform machining by use of a transfer device, such as an overhead traveling crane. Or alternatively, it is possible to adopt a construction in which for the electrical connection between the feed controller 8 including NC control and each of the servo motors 24, 24 having a rotary encoder, a speed detector and the like, the number of energizing channels of the energized body 45 and the energized 46 for the above-described machining power supply connection so that connection is performed at the same time with the installation of the machining unit. Or alternatively, it is possible to adopt a construction in which those similar to the above-described energized body and energization part are provided separately from those for the machining power supply or additionally in a standing manner outside the machining tank 4 or on the bed or provided in the bottom part of the machining tank 4 or on the bottom plate 20. Or alternatively, it is possible to adopt a construction in which the object to be machined 7 is placed on the bottom plate 20 on a cross slide table which permits positioning in horizontal X-Y axis directions and servo feed control. The shapes, sizes and the like of each of the component part can be freely designed and changed within the scope of the object of the present invention, and the present invention includes all of them.

[Advantages of the Invention]

Because the constitution of the present invention is as described above, the present invention can provide a novel electric discharge machining apparatus which enables machining speed response and high-accuracy feeds to be performed, permits the cost reduction of a machining feed mechanism and can prevent an abnormal ignition due

to a liquid level decrease because the control of the machining liquid can be easily performed.

4. Brief Description of the Drawings

[Figure 1]

Figure 1 is a view to explain an embodiment of an electric discharge machining apparatus related to the present invention.

[Figure 2 and 3]

Figures 2 and 3 are each a partial sectional view which shows an embodiment of a machining feed mechanism of a machining unit in the electric discharge machining apparatus shown in Figure 1.

1 ... Electric discharge machining apparatus

2 ... Bed

3 ... Crane

4 ... Machining tank

5, 31 ... Machining unit

6 ... Forming electrode

7 ... Object to be machined

8 ... Controller

9 ... Machining liquid

10 ... Machining liquid supply tank

11 ... Valve

12 ... Pole

13 ... Arm

14 ... Hoist

15 ... Roller

16 ... Motor

17 ... Wire

18 ... Hook

19 ... Operation section

20, 32 ... Bottom plate

21, 33 ... Top plate

22, 34 ... Movable plate

23 ... Support feed screw

24 ... Servomotor

25, 38 ... Bellows

26, 39 ... Bearing

27 ... Holding plate

28, 41 ... Bracket

29 ... Coupling

30 ... Eye bolt

35 ... Support guide shaft

36 ... Bush

37 ... Feed screw

40 ... Nut

42, 43 ... Bevel gear

Patent Applicant, Inoue Japax Research Inc.

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Figure 1

1 Electric discharge machining apparatus

3 Crane

4 Machining tank

5 Machining unit

6 Forming electrode

7 Object to be machined

8 Controller

9 Machining liquid

Figure 2

5 Machining unit

20 Bottom plate

21 Top plate

22 Movable plate

23 Support feed screw

24 Servomotor

Figure 3

31 Machining unit

32 Bottom plate

33 Top plate

34 Movable plate

24 Servomotor

35 Support guide shaft

37 Feed screw

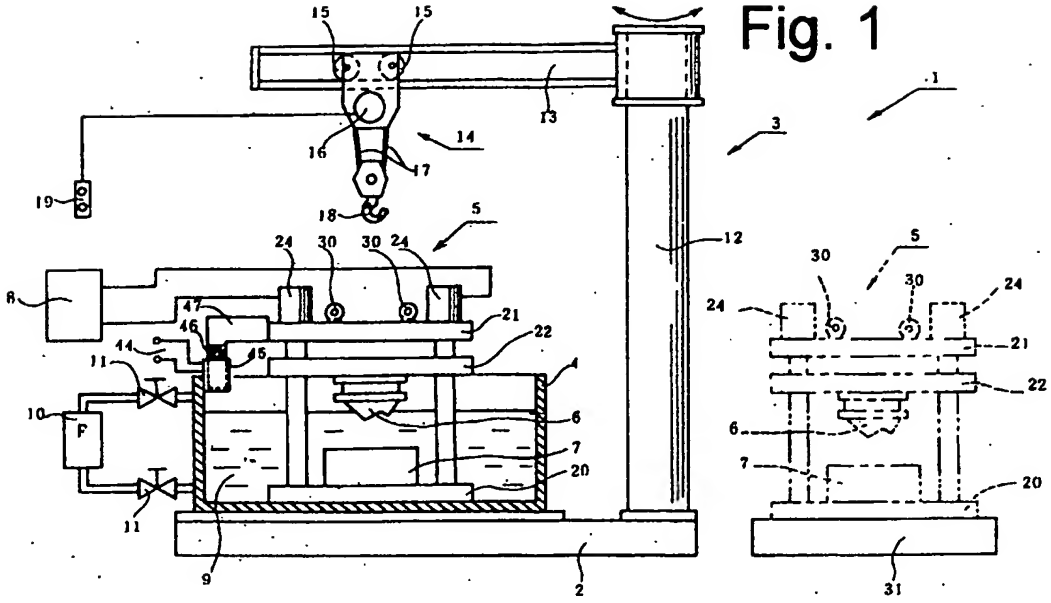
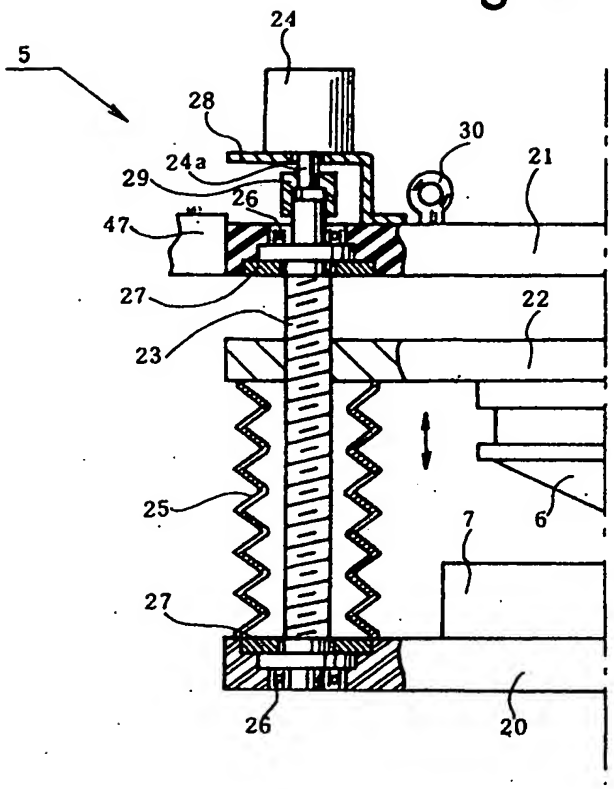


Fig. 1

1	Electric discharge machining apparatus
3	Crane
4	Machining tank
5	Machining unit
6	Forming electrode
7	Object to be machined
8	Controller
9	Machining liquid

Fig. 2



5	Machining unit
20	Bottom plate
21	Top plate
22	Movable plate
23	Support feed screw
24	Servomotor

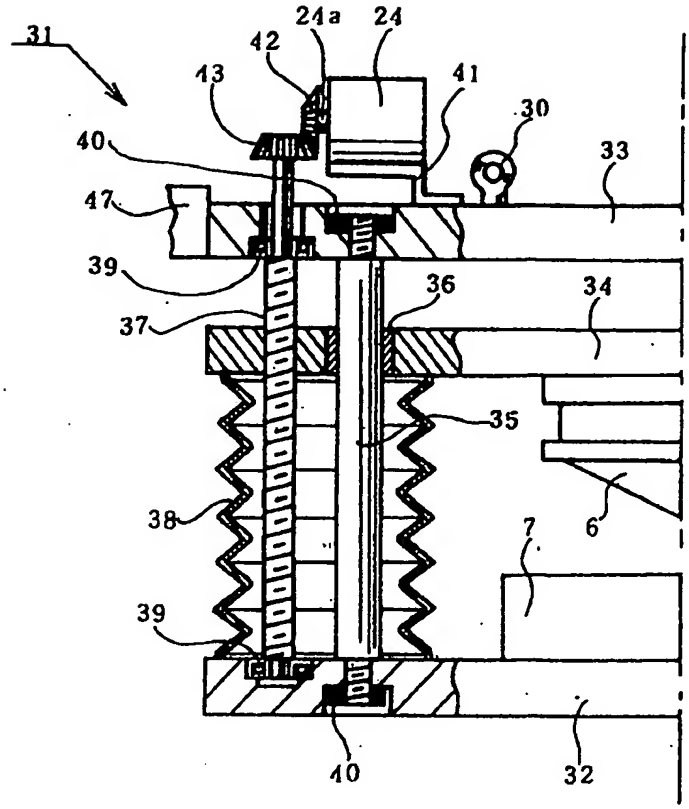


Fig. 3

31	Machining unit
32	Bottom plate
33	Top plate
34	Movable plate
24	Servomotor
35	Support guide shaft
37	Feed screw